CLAIMS

Sub A1

1. A method of determining the structural health of a body; the method comprising the steps of identifying at least one phase characteristic of a signal represented by first data, the first data being derived from the body while bearing at least a guided wave produced in response to application of at least one excitation signal to the body, and providing a measure of the structural health of the body using the at least one phase characteristic.

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2. A method as claimed in any preceding claim, in which the step of identifying the phase characteristic comprises the step of calculating a phase modulation of the first data using $\phi(t) = \arctan\frac{\hat{x}(t)}{x(t)}$, where $\hat{x}(t)$ is the Hilbert transform of the signal represented by the first data and x(t) is the signal represented by the first data.

3. A method as claimed in claim 2, in which the step of providing the measure of structural health comprises the step of determining the amplitude of the phase modulation.

4. A method as claimed in claim 3, in which the step of determining the amplitude of the phase modulation comprises the step of determining the maximum amplitude of the phase modulation.

Sub A2

5. A method as claimed in any preceding claim, in which the step of identifying comprise the steps of taking the Fourier transform of the first data and applying the convolution theorem which gives

$$F[\hat{x}(t)] = \hat{X}(f) = X(f)\{-j\,\mathrm{sgn}(f)\},$$

where sgn(f) is the signum function defined as

$$\mathrm{sgn}(f) = \begin{cases} 1 & for \quad f \geq 0 \\ -1 & for \quad f < 0 \end{cases}$$ where f is frequency.

6. A method as claimed in claim 1, in which the step of identifying comprises the step of comparing the first data with second data, representing the excitation signal launched into the body to produce a guided wave within the body, to identify a phase difference between the first and second data; and in which the at least one phase characteristic comprises the phase difference.

7. A method as claimed in claim 1, in which the step of identifying comprises the step of comparing the first data with second data, representing a previously determined response of the body to bearing a guided wave produced in response to the excitation signal being launched into the body, to identify a phase difference between the first and second data; and in which the at least one phase characteristic comprises the phase difference.

Sub A3

8. A method as claimed in either of claims 6 and 7, in which the phase difference is calculated using a cross-correlation function

$$R(\tau)=\sum_{t=1}^{N} x_{ref}(t)x(t+\tau),$$

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where $R(\tau_i)$ is the cross-correlation function between the first and second data and N is the number of data samples of the first and second data.

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9. A method as claimed in claim 8, in which the measure of structural health is given by at least one of $D=1-R(\tau_i)$ or $D=1/R(\tau_i)$.

Sub A4

10. A method as claimed in any of claims 6 to 9, in which the step of providing comprises the step of identifying the magnitude of the instantaneous phase difference between the first and second data.

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11. A method as claimed in any preceding claim, in which the guided wave is a Lamb wave.

12. A method as claimed in any preceding claim, further comprising the steps of attaching a first transducer to the body and applying the excitation signal to the first transducer to induce the propagation of the guided wave within the body.

13. A method as claimed in any preceding claim, further comprising the step of attaching

a second transducer to the body and measuring the response of the second transducer to the presence of the guided wave.

Sub A4 cont.

14. A method as claimed in any preceding claim, further comprising the steps of applying a third transducer to the body and applying a second excitation signal to the third transducer.

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15. A method as claimed in any preceding claim, in which the excitation signal applied to a transducer is arranged to produce a guided wave having a predetermined frequency.

16. A method as claimed in claim 15, in which the predetermined frequency is selected according to the dimensions of an anticipated defect within the body.

Sub A5

17. A method as claimed in any preceding claim, in which the excitation signal is arranged to have at least one predetermined frequency component.

18. A method as claimed in claim 17, in which the at least one predetermined frequency component comprises at least one frequency component that is related to at least one of a desired mode of propagation of the guided wave and the thickness of the material under test, preferably, the at least one predetermined frequency component comprises at least one frequency component in the range 80 kHz to 10 MHz.

19. A method as claimed in either of claims 17 and 18, in which the at least one predetermined frequency component comprises at least one frequency component in the range 1 Hz to 10 kHz.

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20. A method as claimed in any preceding claim, in which the excitation frequency is selected to induce a predetermined mode of propagation of the guided wave within the body.

21. A method as claimed in any preceding claim, in which the excitation signal predetermined frequency is selected according to a resonant mode of the first transducer.

22. A method as claimed in any of claims 6 and 21, in which the step of providing the measure of structural health comprises the step of comparing the amplitude of the phase modulation with the amplitude of the excitation signal.

23. A method for monitoring the structural integrity of a body substantially as described herein with reference to and/or as illustrated in the accompanying drawings.

Sub A6

24. An apparatus for determining the structural health of a body; the apparatus comprising means for identifying at least one phase characteristic of a signal represented by first data, the first data being derived from the body while bearing at least a guided wave produced in response to application of at least one excitation signal to the body, and means for providing a measure of the structural health of the body using the at least one phase characteristic.

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25. An apparatus as claimed in claim 24, in which the means for identifying the phase characteristic comprises means for calculating a phase modulation of the first data using $\phi(t) = \arctan\frac{\hat{x}(t)}{x(t)}$, where $\hat{x}(t)$ is the Hilbert transform of the signal represented by the first data and x(t) is the signal represented by the first data.

26. An apparatus as claimed in claim 25, in which the means for providing the measure of structural health comprises means for determining the amplitude of the phase modulation.

27. An apparatus as claimed in claim 26, in which the means for determining the amplitude of the phase modulation comprises means for determining the maximum amplitude of the phase modulation.

Sub A7

28. An apparatus as claimed in any of claims 24 to 27, in which the means for identifying comprises means for taking the Fourier transform of the first data and means for applying the convolution theorem which gives

$$F[\hat{x}(t)] = \hat{X}(f) = X(f)\{-j\,\mathrm{sgn}(f)\},$$

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where sgn(f) is the signum function defined as

$$\mathrm{sgn}(f) = \begin{cases} 1 & for \quad f \geq 0 \\ -1 & for \quad f < 0 \end{cases},$$ where f is frequency.

Sub A7 cont.

29. An apparatus as claimed in claim 24, in which the means for identifying comprises means for comparing the first data with second data, representing the excitation signal launched into the body to produce a guided wave within the body, to identify a phase difference between the first and second data; and in which the at least one phase characteristic comprises the phase difference.

30. An apparatus as claimed in claim 24, in which the means for identifying comprises means for comparing the first data with second data, representing a previously determined response of the body to bearing a guided wave produced in response to the excitation signal launched being launched into the body, to identify a phase difference between the first and second data; and in which the at least one phase characteristic comprises the phase difference.

Sub A8

31. An apparatus as claimed in either of claims 29 and 30, in which the phase difference is calculated using a cross-correlation function

$$R(\tau)=\sum_{t=1}^{N} x_{ref}(t)x(t+\tau),$$

where $R(\tau_i)$ is the cross-correlation function between the first and second data and N is the number of data samples of the first and second data.

32. An apparatus as claimed in claim 31, in which the measure of structural health is given by at least one of $D=1-R(\tau_i)$ or $D=1/R(\tau_i)$.

Sub A9

33. An apparatus as claimed in any of claims 29 to 32, in which the means for providing comprises means for identifying the magnitude of the instantaneous phase difference between the first and second data.

34. An apparatus as claimed in any of claims 24 to 33, in which the guided wave is a Lamb wave.

35. An apparatus as claimed in any of claims 24 to 34, further comprising means for attaching a first transducer to the body and means for applying the excitation signal to the first transducer to induce the propagation of the guided wave within the body.

36. An apparatus as claimed in any of claims 24 to 35, further comprising means for

Sub A9 cont.

attaching a second transducer to the body and means for measuring the response of the second transducer to the presence of the guided wave.

37. An apparatus as claimed in any of claims 24 to 36, further comprising means for applying a third transducer to the body and means for applying a second excitation signal to the third transducer.

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38. An apparatus as claimed in any of claims 24 to 37, in which the excitation signal applied to the transducer is arranged to produce a guided wave having a predetermined frequency.

39. An apparatus as claimed in claim 38, in which the predetermined frequency is selected according to the dimensions of an anticipated defect within the body.

Sub A10

40. An apparatus as claimed in any of claims 24 to 39, in which the excitation signal is arranged to have at least one predetermined frequency component.

41. An apparatus as claimed in claim 40, in which the at least one predetermined frequency component comprises at least one frequency component that is related to at least one of desired mode of propagation of the guided wave and the thickness of the material under test and preferably comprises at least one frequency component in the range 80 kHz to 10 MHz.

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42. An apparatus as claimed in either of claims 40 and 41, in which the at least one predetermined frequency component comprises at least one frequency component in the range 1 Hz to 10 kHz.

43. An apparatus as claimed in any of claims 24 to 42, in which the excitation frequency is selected to induce a predetermined mode of propagation of the guided wave within the body.

44. An apparatus as claimed in any of claims 24 to 43, in which the excitation signal predetermined frequency is selected according to a resonant mode of the first transducer.

45. An apparatus as claimed in any of 24 to 44, in which the means for providing the measure of structural health comprises means for comparing the amplitude of the

Sub A10 CONT.

phase modulation with the amplitude of the excitation signal.

46. An apparatus for monitoring the structural integrity of a body substantially as described herein with reference to and/or as illustrated in the accompanying drawings.

Sub A11 47. A computer program element for implementing a method or system as claimed in any preceding claim.

48. A computer program product comprising a computer readable storage medium having stored thereon a computer program element as claimed in claim 47.